

Structure and Properties of Atoms

PS-2 The student will demonstrate an understanding of the structure and properties of atoms.

PS-2.5 Predict the charge that a representative element will acquire according to the arrangement of electrons in its outer energy level.

Taxonomy Level: 2.5-B Understand Conceptual Knowledge

Key Concepts:

Chemical stability: chemically stable atom, chemically unstable atom

Valence electrons

Chemical reaction

Compound

Ion

Previous/Future knowledge: Students have not studied subatomic particles prior to Physical Science, so this is the first experience students will have with the idea that the number of outer-level electrons determines the chemical stability of an atom, and that atoms tend to gain, lose, or share electrons in order to become chemically stable. Fundamental knowledge of the fact that some elements are chemically stable and do not react chemically, that most elements are not chemically stable and do react chemically and how atoms achieve a chemically stable situation with reference to outer-level electron arrangement of the atom is essential for all of the study of chemistry. As this is an introduction to the concept of ionization, emphasis should be placed on those groups of elements that are likely to gain or lose 1 or 2 electrons, and on the Noble Gases.

It is essential for students to

- Understand that there are only a few *chemically stable* atoms. These are the Noble Gases. Understand that data shows that these stable atoms contain 8 valence electrons (or 2 for helium). Atoms that do not contain 8 valence electrons in the neutral state (when the number of electrons equals the number of protons) tend to gain, lose or share valence electrons in order to achieve stability.
 - All of the theory depends on the observable behavior that showed that there were some elements that did not undergo chemical change (normally).
- Understand that only electrons are involved in chemical reactions.
 - In chemical reactions, the number of protons and the number of neutrons remain constant.
- Determine (by using a periodic table) the number of protons and the number of electrons a neutral atom of a given element contains. (PS-2.3)
- Understand that atoms tend to lose, gain or share electrons to have the same number of *valence electrons* (electrons in the outer-most energy level) as one of the stable elements, i.e., the Noble Gases.
- Predict how many electrons an atom of a given element will gain or lose in order to most readily reach chemical stability based on the following generalizations:
 - The elements in group 18 are stable as they are with 2 or 8 electrons in the outer energy level and, therefore, do not gain or lose electrons except under extreme conditions.
 - The elements in groups 1 and 2 tend to lose 1 and 2 electrons respectively.
 - The elements in groups 16 and 17 tend to gain 2 and 1 electron respectively.
 - The elements in groups 13-15 are less likely than those listed above to either gain or lose electrons because they have 3, 4, and 5 valence electrons respectively. Students are **not**

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responsible for predicting the charges of elements from groups 13-15 as these elements tend to share electrons rather than gain or lose electrons.

- Most of the transition elements (groups 3-12) tend to lose electrons.
- Understand that if a neutral atom loses electrons, the particle formed will have a positive charge and if a neutral atom gains electrons, the particle formed will have a negative charge. The charged particle is called an *ion*.
 - Understand that the ion formed is chemically stable.
 - Reconcile the number of protons and electrons in the resulting ion and determine the excess positive or negative charge.
- Refine their definition of metals as elements that tend to lose electrons and non-metals as elements that tend to gain electrons. (Students distinguished metals from nonmetals by their position on the periodic table and their observable properties in 7th grade and in PS-2.3)
 - Students should be aware that some of the chemical properties of metals and nonmetals are due to their tendency to lose or gain electrons.

It is not essential for students to

- Understand reasons that there are exceptions to ionization trends or be able to cite exceptions to trends; (Students should, however, realize that there are exceptions.)
- Understand how the size of some elements influences whether they gain or lose electrons. (Metalloids)

Assessment Guidelines:

The objective of this indicator is for students to *predict* the charge that a representative element will acquire based on the number of electrons the element has in its outer-most energy level, therefore, the primary focus of assessment should be to show that students can use knowledge of chemical stability and the relationship between an element's position on the periodic table and outer-shell electron arrangement to predict whether an atom will gain or lose electrons, and how many electrons will be involved. Assessments should test the students' ability to infer the charge for the chemically stable ion formed from any element or set of elements (elements not mentioned in the instructional guidelines are not essential).

In addition to *predict*, assessments may require students to

- *Summarize* atomic properties that are a result of an atom's tendency to gain, lose, or share electrons;
- *Exemplify* elements that can form ions with like charges;
- *Interpret* diagrams that depict outer-shell electron arrangement;
- *Compare* charges of stable ions that are likely to form from elements within the same family and between families of representative elements.